NOVA SCOTIA
Department of Health

Lead and Arsenic Biological Testing Program

In Residential Areas Near the Coke Ovens Site

Nova Scotia Department of Health and the Cape Breton District Health Authority

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Executive Summary

This report provides the results of the biological testing program for lead and arsenic in Sydney, Nova Scotia. This program was carried out by the Nova Scotia Department of Health and the Cape Breton District Health Authority in the summer of 2001. The purpose of this testing program was to assess individual current exposure to lead and arsenic in the population living near the Coke Ovens site in Sydney, Nova Scotia.

The primary objectives of this testing program were;

- To provide residents living near the Coke Ovens site with the opportunity to have an assessment of their current exposure to lead and arsenic through confidential, personal laboratory testing of their blood and urine.

- To provide individuals with scientifically-based advice on reducing individual exposure if required, and on methods to achieve such reduction.

- To provide summary results (not linked to any one individual) which will inform the broader efforts in the community health risk assessment of the residents living near the Coke Ovens.

A multi-disciplinary team developed a testing protocol. Testing was offered to all children age 1 to 5 and all pregnant women in neighbourhoods around the Coke Ovens site (Whitney Pier, North End, and parts of Ashby). In addition, all residents in the area north of the Coke Ovens (NOCO) were offered testing. Some individuals in these neighbourhoods sought testing independently through their family physicians.

Tests were conducted for blood lead and urinary inorganic arsenic. Individuals with levels above 10 ug/dL of lead in blood or above 20 ug/L of inorganic arsenic in urine were investigated further.

In total, 372 people in the target area were tested for lead including 186 children age 1 to 5. This represents 44% of the children age 1 to 5, 61% of the pregnant women and 30% of residents of NOCO. Blood lead levels averaged 1.86 ug/dL for all ages tested and 1.86 ug/dL for children. This is well below the level of 10 ug/dL designated as the level at which follow up would be done. Two adults had a level above 10 ug/dL. No children were above this level. There was no difference between neighbourhoods. Men generally had higher blood lead levels than women. These levels are consistent with other populations in North America who are not exposed to unusual sources of lead.

Three hundred and seventy-two (372) persons from the target area were tested for urinary inorganic arsenic including 179 children ages 1 to 5. Forty two percent (42%) of the children, 61% of pregnant women and 30% of residents of NOCO were tested. Urinary inorganic arsenic levels averaged 4.49 ug/L for all ages tested and 3.75 ug/L for children. There was no difference by neighbourhood or gender. Ninety-six percent (96%) of the results were below 20 ug/L, the level at which detailed follow up took place. Of the 15 individuals with levels above 20 ug/L on the initial test, only 2 remained above this level after definitive confirmatory testing done on 24-hour urine samples. The urinary inorganic arsenic levels in Sydney were comparable to the three Canadian communities for which data were available, with the exception of the maximum level in Sydney which was higher than in the other three communities. The proportion of results at or above 20 ug/L was 4% in Sydney compared to 1.6 to 3.3% for the other communities. The

Sydney results were below reported levels in European populations in areas without localized sources of arsenic.

While this biological testing program has some limitations, it has met its objectives. Residents living near the Coke Ovens were provided with the opportunity to be tested for lead and arsenic and have received their personal results and interim advice on reducing exposure if required. Further advice will be given after the property-specific chronic risk assessments are completed.

The results reflecting lead exposure in the community are very reassuring. Blood lead levels in this community are low, and reflect levels of exposure similar to areas where there is no identifiable soil lead exposure source. From a public health perspective, this community is not at increased risk from lead in soil.

On the community level, arsenic exposure is also low. While there were individuals with initial results higher than the general population of those tested, all but two of these were within the same range as the general population on repeat confirmatory testing. The overall community profile resembles other areas, both with and without localized sources of arsenic in soil.

The results and conclusions from this biological testing program will be considered alongside the results of the property-specific chronic risk assessments in order to develop further recommendations if required.

Introduction

The Muggah Creek Watershed in the Cape Breton Regional Municipality (CBRM) is the focus of a multi-phased environmental assessment and remediation project. The site includes the Sydney Tar Ponds, the Coke Ovens Site and the Municipal Landfill. Recent environmental sampling north of the Coke Ovens (NOCO) identified lead and arsenic as possible substances of concern in the soil. This led to considerable concern among area residents and to a decision by the Nova Scotia Department of Health and the Cape Breton District Health Authority to test area residents for lead and arsenic. At the same time, Health Canada decided to carry out detailed assessments of properties to determine long-term risks to health.

This report provides the results of the biological testing program (for all results available to the end of October 2001). Detailed information on the testing program can be found in the testing program protocol (Nova Scotia Department of Health 2001).

The purpose of the biological testing program was to assess individual current exposure to lead and arsenic in the population living near the Coke Ovens site and to provide advice to reduce exposure, if required. Reducing exposure is a primary prevention strategy, which will minimize any potential adverse health effects in the long term.

Lead is widespread in the environment and a strong positive correlation has been found between exposure to lead-contaminated soils and blood lead levels (Centers for Disease Control 1991). Children, in particular, are more at risk from lead in the environment due to physiological characteristics, which make them more sensitive to lead than adults, and their outdoor play activities, which make them likely to have higher exposures than adults. The health effects of lead include central nervous system manifestations in children leading to neuro-cognitive deficiencies. Since these effects can start in utero, the exposure of pregnant women to lead is also a concern.

Arsenic compounds, inorganic as well as organic, are everywhere in the environment. Inorganic arsenic compounds are generally considered more toxic than organic compounds. Adverse health effects following ingestion of drinking water with inorganic arsenic or inhalation of inorganic arsenic compounds are well documented. The relationship between arsenic in soil and human health effects is not as clear.

Assessment of exposure is usually done by constructing exposure scenarios looking at pathways of exposure and concentrations in food, water, air, soil etc. to calculate a total amount that gets into the body. This is then compared to levels determined to be safe, which are derived from animal and human health studies. The resulting estimate may have substantial scientific uncertainty (Pirkle et al 1995). A more direct way to assess human exposure is to directly measure the level of the substance in accessible human tissues or body fluids. This type of information is complimentary to environmental sampling and monitoring.

Purpose and Objectives of the Testing Program

The purpose of this testing program was to assess individual exposure to lead and arsenic in the population living near the Coke Ovens site in Cape Breton, Nova Scotia. Lead and arsenic are found in the soil on the Coke Ovens site and in the area north of the Coke Ovens (NOCO).

The primary objectives of this testing program were:

- To provide residents living near the Coke Ovens site with the opportunity to have an assessment of their current exposure to lead and arsenic through confidential, personal laboratory testing of their blood and urine

- To provide individuals with scientifically-based advice (based on the testing results) on reducing individual exposure if required, and methods to achieve such reduction

- To provide summary results (not linked to any one individual) which will inform the broader efforts in the community health risk assessment of the residents living near the Coke Ovens

Methods

A team that included public health nurses, a toxicologist, specialist physicians, medical officers of health and an epidemiologist designed this testing program. Input was sought from specialists in environmental health and laboratory medicine.

It is important to note that people tested were not randomly selected but voluntarily came forward for testing.

Target Population and Area

Testing for blood lead and urinary inorganic arsenic (first void urine) was offered through public health operated community-based clinics. The target population and target area for testing were:

- Pregnant women (23 women) in Whitney Pier (WP), parts of Ashby, and North End Sydney (NE)
- Children age 1 to 5 inclusive in Whitney Pier, parts of Ashby, and North End Sydney (424 children)
- All residents in the residential area of Whitney Pier designated for environmental assessment purposes as NOCO (220 including children and pregnant women).
- Family members residing with individuals who tested above the level set for follow up.
- Residents of properties tested by Health Canada where short term exposure limits for lead and arsenic in soil were exceeded.

Participants were recruited through radio, television and newspaper advertising and community flyers. Informed consent was obtained and blood and urine were collected, stored and shipped according to standard procedures to a laboratory specializing in trace metal testing. Participants were advised to avoid fish or seafood for two days prior to urine collection.

In addition, some individuals and families in the target area requested testing through their family physicians. This included individuals both in and outside of the target population.

About 37 individuals who live outside the target area and were not in the target population sought testing. The results for these individuals are reported separately in

order to compare results of individuals outside the target area with those inside the target area. They appear in the tables as "Others tested-outside the target area."

The same tests were done for all the participants. Under provincial public health legislation, the results for tests done through the family physician were available to the Provincial Medical Officer of Health on request. Since this is important information for making public health decisions, the Provincial Medical Officer of Health received this information under the authority of the Health Act. However, it is important to note that only age, gender, neighbourhood and laboratory results were entered into the database.

The population in the target area is shown in Table 1.

Table 1: Population in the Target Area

	Part of Ashby	NOCO only	WP not including NOCO	North End	Total
Children 1 to 5 years	67	8	269	80	424
Older children and adults*	877	212	5423	1773	8285
Total**	944	220	5692	1853	8709

*Includes 23 pregnant women
** Total is not limited to the target population but includes all residents in the target area (Statistics Canada 1996 census data).

Laboratory methods

Blood was analyzed for lead by inductively coupled plasma mass spectrometry (ICP-MS). The detection limit is 0.0005 micromoles/L (0.01 ug/dL).

Arsenic occurs in organic (e.g. seafood) and inorganic forms. Organic forms are generally believed to be less harmful to humans than inorganic forms. While both exist in the environment, inorganic arsenic is the contaminant of concern so analysis was limited to this form. Inorganic arsenic in this testing program includes As 3+, As 5+, monomethylated arsenic (MMA) and dimethylated arsenic (DMA). These forms of arsenic were reported by the laboratory together as inorganic arsenic. Urine was analyzed for inorganic arsenic by ICP-MS with a detection limit of 0.007 micromoles/L (0.5 micrograms/L).

Notification of results to individuals

Each individual tested by public health received notification of his or her results in a personal letter as soon as results were available. The letter included an interpretation of the results and a contact name and number for further information. Individuals tested by their physician received results directly from their physician.

Follow up of individuals

For findings requiring follow up, the individual was personally informed of his or her results along with an interpretation of the results. With the participant's permission the information was shared with his or her family doctor.

Public Health staff followed up individuals with a blood lead level of 10 ug/dL or above or a urinary inorganic arsenic level of 20 ug/L or above. These follow up levels were determined prior to testing being initiated by considering medical literature, consultation with experts and review of other community-based studies. Follow up included confirmatory testing, an interview focused on known sources of exposure to lead or arsenic, environmental testing of the property, testing of other family members for similar exposure and medical assessment by family physicians or specialists as required. Confirmatory testing for inorganic urine arsenic involved measuring concentration on a 24 hour urine sample. This is a more definitive test than first void urine, but is not practical to do in large numbers. Recommendations for reduction of exposure were made if appropriate.

Data Analysis

Demographic variables such as age, gender, neighbourhood and laboratory results were entered into a database (Microsoft Access 2000) and exported to Minitab (Version 13) as required for statistical analysis. A statistician was consulted on all analyses.

All participants in the target area were considered as one group for analysis. This included children and pregnant women. In addition, data for children ages 1 to 5 were analyzed separately since age is related to exposure patterns, and additionally, this is the group of most concern. Basic information on pregnant women is provided. A glossary of statistical terms is provided as an appendix to assist in the interpretation of the data.

The distributions for both lead and arsenic results were skewed. Most results were clustered in the lower end of the scale. Since they did not follow a normal statistical distribution the lead and arsenic results were examined using non-parametric statistical methods. The data were also examined using parametric methods on both the raw and log-transformed data.

Comparisons were made between all those tested by neighbourhood and again for those age five and under by neighbourhood. To examine the differences among neighbourhoods, the Kruskal-Wallis test for non-parametric data was employed. The Mann - Whitney U test was used to examine differences between the medians (as a measure of central tendency) of gender groups. Gender effects were examined for differences among neighbourhoods (i.e. interactions) on all those tested using a parametric method (ANOVA -general linear model) on log transformed data.

A significance level of 5% was used to accept differences as statistically significant.

Box and whisker plots and frequency distributions in the form of histograms are shown to illustrate blood lead and urine inorganic arsenic results. (See glossary at the end of the document)

Blood Lead Results

Number tested

Three hundred and seventy two (372) individuals in the target area were tested for blood lead. Table 2 shows the number of individuals tested by age category and neighbourhood. Forty-four percent (44%) of the children and 61% of pregnant women in the target area were tested. Thirty percent (30%) of residents of NOCO were tested. Thirty-seven (37) individuals who live outside the target area sought testing as well.

No information was available on people who chose not to be tested, so it is not possible to determine if there are differences in any characteristics between those tested and those who chose not to be tested.

Table 2: Number of Tests for Blood Lead by Age Group and Neighbourhood (% of target population where applicable)

	Part of Ashby	NOCO	Whitney Pier not including NOCO	North End	Total
Children Age 1 to 5	36 (54%)	6 (75%)	106 (39%)	38 (48%)	186 (44%)
Older Children and Adults*	20	60	85	21	186
All tested (in the target area)	56	66 (30%)	191	59	372
Others tested (Outside the target area)	-	-	-	-	37

* Includes 14 pregnant women tested out of a possible 23 (61%).

Blood Lead Results for All Tested in the Target Area

Figures 1 to 3 show the results for blood lead levels for all those tested in the target area. The frequency distribution in Figure 1 shows that the results for lead were clustered below 3 ug/dL with only a few higher values. This is further illustrated in the box plot in Figure 2. 50% of the results were below 1.86 ug/dL (the median) while 75% of the results were below 2.49 ug/dL. Two individuals had blood lead levels above 10 ug/dL. These were both adults living in NOCO. The blood lead results for each neighbourhood are shown in Figure 3. There is no significant difference in blood lead results from people in different neighbourhoods including those outside the target area (Other). There was a statistically significant difference in blood lead results for gender with males having a higher median value than females. This was not related to neighbourhoods (i.e. no interaction). Fourteen pregnant women were included in this group. The median blood lead level for pregnant women was 1.24 ug/dL with a maximum value of 2.28 ug/dL.

Figure 1: Frequency Distribution of Blood Lead All tested, All ages (n=372)

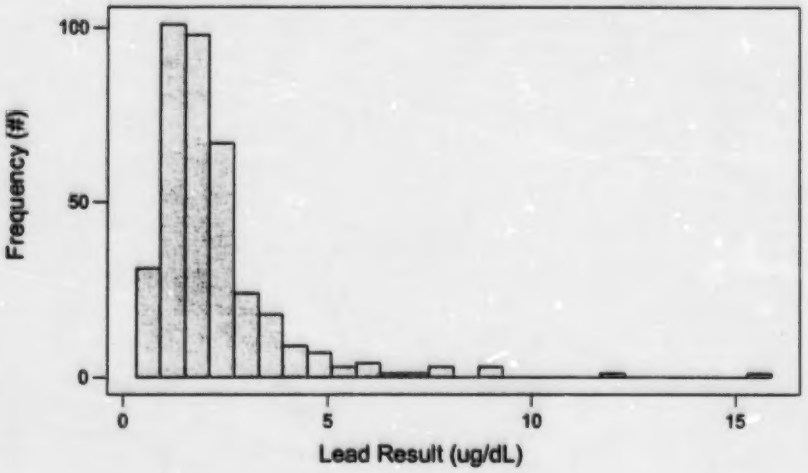


Figure 2: Box Plot of Blood Lead All tested, All ages (n=372)

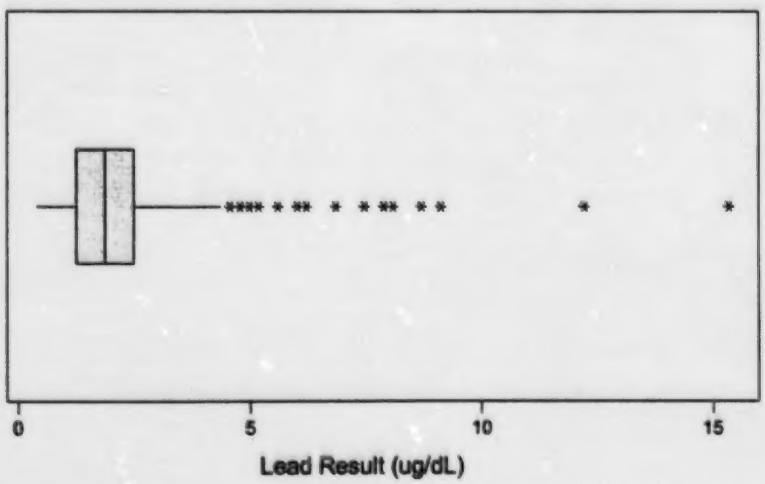
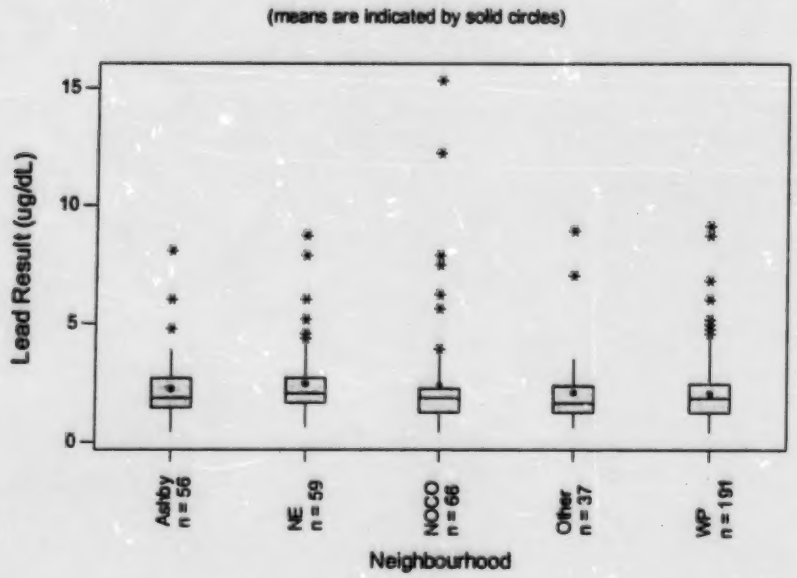


Figure 3: Box Plot of Blood Lead Levels All tested, All ages by Neighbourhood



Blood Lead Results for Children 1 to 5

Figures 4, 5 and 6 show the results for children only. The frequency distribution in Figure 4 shows that the results for children were clustered between 1 and 3 ug/dL. This is further illustrated in the box plot in Figure 5. Fifty percent (50%) of children had a blood lead level below 1.87 ug/dL while 75% were below 2.69 ug/dL. No children were above 10 ug/dL: the level at which further investigation of environmental sources of lead should occur. The results are shown for each neighbourhood separately in Figure 6. Note that there was no difference by neighbourhood including those who live outside the target area (Other). There was no difference in results between males and females.

Figure 4: Frequency Distribution of Blood Lead Levels All tested, Children 1 to 5 (n=186)

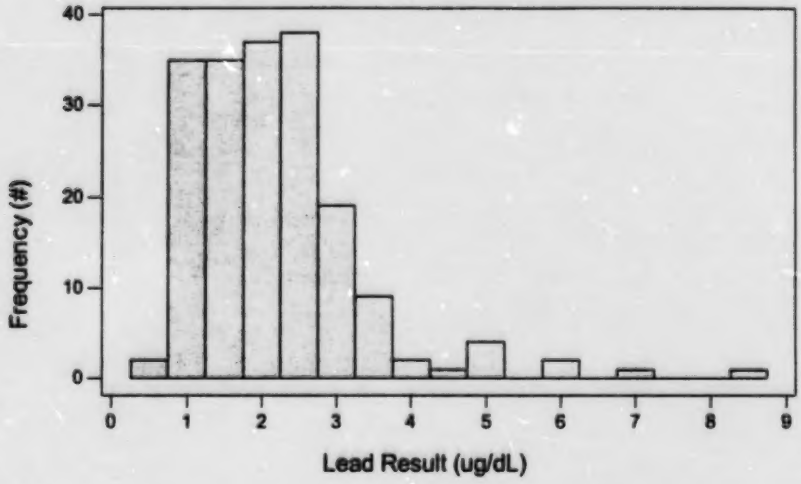


Figure 5: Box Plot of Blood Lead Levels All tested, Children 1 to 5 (n=186)

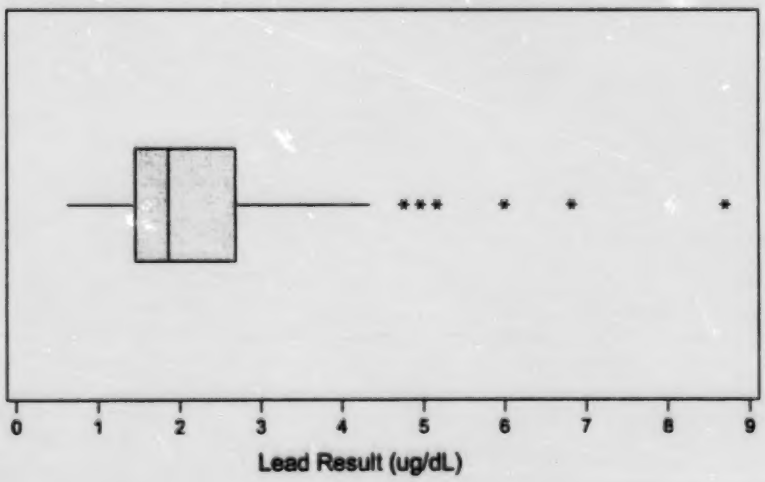
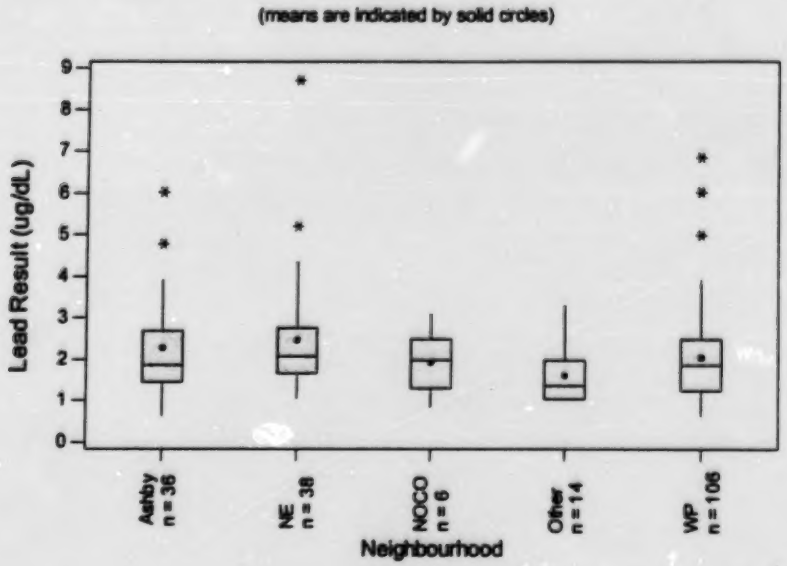


Figure 6: Box Plot of Blood Lead All tested, Children 1 to 5 by Neighbourhood



The blood lead results are summarized in Table 3 for easy reference.

Table 3: Summary of Blood Lead Results (ug/dL) by Group for all Ages and for Children

		N	Arith-metic Mean	Geometric Mean	Median	Min	Max	25th percentile	75th percentile
All Ages	All Tested in Target Area	372	2.22	1.88	1.87	0.41	15.33	1.24	2.49
	Others	37	2.10	1.77	1.66	0.62	8.91	1.24	2.38
Children 1 to 5 years	All Tested in Target Area	186	2.18	1.96	1.87	0.62	8.70	1.45	2.69
	Others	14	1.61	1.51	1.35	1.04	3.12	1.04	1.97

Individuals Requiring Follow Up

Two individuals out of 372 (0.5%) had blood lead levels above 10 micrograms/dL (12.0 and 15.3 ug/dL). These were both adults living in the NOCO area. There was no obvious source of exposure found during the follow up investigation, which included a

review of adult-related risk factors for higher lead levels (e.g. occupation, hobbies, lifestyle) etc. Both properties underwent detailed soil sampling and the results were compared against short-term exposure guidelines with no exceedances.
The property-specific chronic risk assessment results are not yet available.

It is important to note that no child had lead levels greater than 10 ug/dL.

Comparison with Other Communities

Blood lead has been extensively examined in children in North America. On last examination, Canadian children's blood lead levels were generally low. However there are no recent Canadian population-based data, although there are many reports of studies on volunteers such as this one. Table 4 shows some findings from other areas.

The Ontario Blood Lead Surveys of 1992 are population-based, not volunteer-based and show mean blood lead values for both remote and urban settings that are higher than the results seen in this testing program. However, it is known that population blood lead levels have been falling so that current levels in Ontario may now be lower than in 1992.

A comparison of results from this testing program to the National Health and Nutrition Examination Survey 1999 in the United States shows that for age 1 and older (including adults), the Sydney group has slightly higher levels. For children ages 1 to 5, the Sydney group is consistently lower.

The Health and Environmental Handbook for Health Professionals provides some guidance for determining whether blood lead levels require a community-based intervention. A community program should be considered if mean blood lead levels in children exceed the mean of the general population plus 3 standard deviations. The purpose of such a program would be to reduce sources of exposure and provide information to the community about methods to reduce individual exposure. No current data on the Nova Scotia population is available. However, the population tested in Sydney does not meet this criterion when compared to the Ontario population or the US population. Another criterion for a community program is met when the percentage of children with blood lead above 10 ug/dL is double that of the general population. In 1990 in Canada 5 % of children exceeded this level. In this testing program no child exceeded this level.

Table 4: Community Comparison of Blood Lead Results (ug/dL)

		N	Mean (SD)	Geometric Mean	25th Percent ile	50th Percent ile	75th Percent ile	90th Percent ile
All ages	Sydney	372	2.22	1.88	1.24	1.86	2.49	3.52
	US Population NHANES 1999	3189		1.6	1.0	1.5	2.3	3.7
Age 1 to 5	Sydney	186	2.18	1.96	1.45	1.86	2.69	3.32
	US Population NHANES 1999	254		2.0	1.3	1.9	2.7	4.7
Ontario Children 1992	Ontario Blood Lead Survey, remote community		3.10 (2.10)					
	Ontario Blood Lead Survey, urban		3.48 (2.22)					

Summary of Blood Lead Results

Three hundred and seventy two (372) individuals from the target area were tested including 186 children ages 1 to 5. Forty-four percent (44%) of the children, 61% of pregnant women and 30% of residents of NOCO were tested.

The median blood lead level was 1.86 ug/dL for all tested in the target area as well as for children, revealing that exposures are generally low. Seventy-five percent (75%) of test results were below 2.49 ug/dL for all ages tested and 2.69 ug/dL for children only. Two adults from NOCO had a level greater than 10 ug/dL, which is the level designated for follow up action in children. No children were above this level. There was no significant difference in blood lead levels between neighbourhoods but there was a significant difference by gender, with males tending to have higher blood lead levels than females. These levels were consistent with other populations in North America who are not exposed to unusual sources of lead.

Based on a comparison with other communities and with criteria for establishing aggressive lead exposure intervention programs, no specific action is required in the target area to reduce exposures on a community level.

Urinary Inorganic Arsenic Results

Number tested

Three hundred and seventy-two (372) individuals in the target area were tested for urinary inorganic arsenic including 179 children aged 1 to 5 years old. Table 5 shows the number of individuals tested by age category and neighbourhood.

Forty-two percent (42%) of the children and 61% of the pregnant women in the target group were tested. Thirty percent (30%) of the residents of NOCO were tested. Thirty-five (35) individuals living outside the target area sought testing as well.

No information was available on people who chose not to be tested, so it is not possible to determine if there are differences in any characteristics between those tested and those who chose not to be tested.

Table 5: Tests for Urinary Inorganic Arsenic by Age Group and Neighbourhood

(% of target population where applicable)

	Part of Ashby	NOCO Only	WP not including NOCO	North End	Total
Children Age 1 to 5	33 (49%)	6 (75%)	106 (39%)	34 (43%)	179 (42%)
Older Children and Adults*	22	60	87	24	193
All tested (in the target area)	55	66 (30%)	193	58	372
Others tested (outside the target area)	-	-	-	-	35

* Includes 14 pregnant women tested out of a possible 23 (61%).

Urinary Inorganic Arsenic Results for All Tested in the Target Area

Figures 7, 8 and 9 show the urinary inorganic arsenic levels for all individuals tested in the target area. The frequency distribution in Figure 7 shows that the urinary inorganic arsenic results were clustered below 10 ug/L. This is further illustrated in the box plot in Figure 8, which shows that 50% of the results were below 4.49 ug/L (the median) while 75% of the results were below 8.05 ug/L.

The results for each neighbourhood are shown in the box plot in Figure 9. Except for the four outliers (2 in NE and 2 in WP) the results were much the same for each neighbourhood. There was no significant difference in urinary inorganic arsenic levels by neighbourhood or gender.

Fourteen pregnant women were tested. The median urinary inorganic arsenic level was 4.11 ug/L for these women, with a maximum level of 8.98 ug/L.

Figure 7: Frequency Distribution of Urinary Inorganic Arsenic All tested, All ages (n=372)

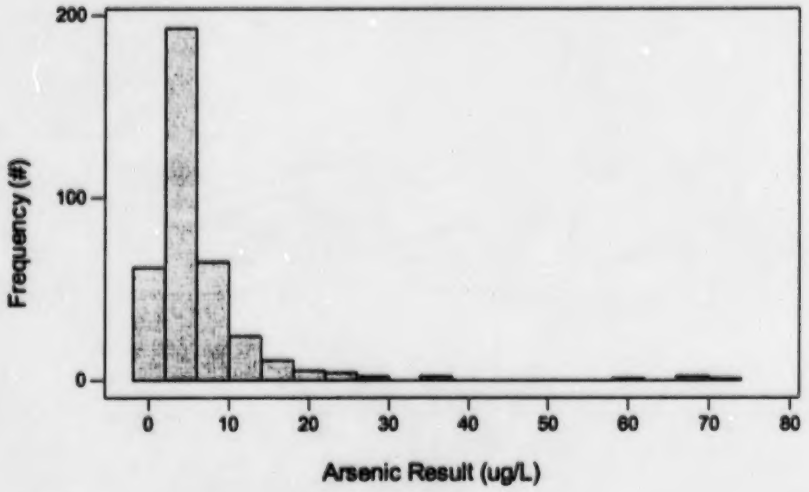


Figure 8: Box Plot of Urinary Inorganic Arsenic All tested, All ages (n=372)

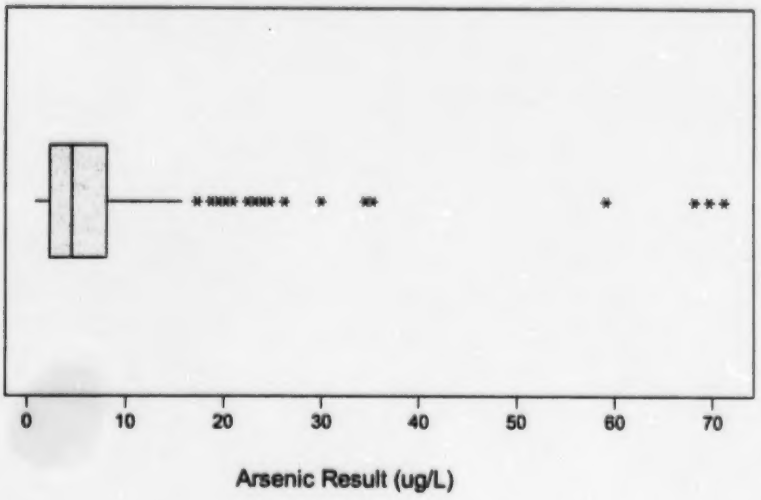
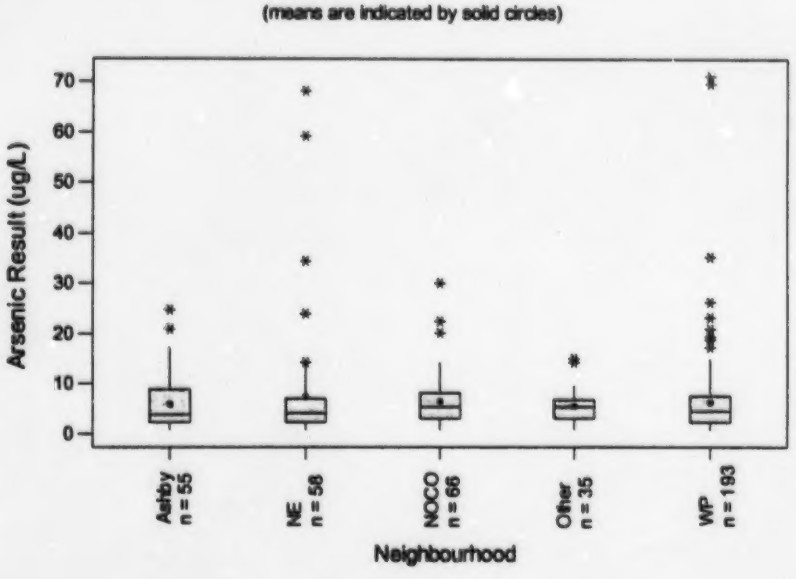


Figure 9: Box Plot of Urinary Inorganic Arsenic All tested, All ages By Neighbourhood



Urinary Inorganic Arsenic Results for Children 1 to 5

The urinary inorganic arsenic results for children only are shown in Figures 10, 11 and 12. The frequency distribution shows that the results clustered below 10 ug/L. As shown in the box plot in Figure 11, 50% of children had urinary inorganic arsenic levels below 3.75 ug/L (the median) while 75% of children were below 8.24 ug/L. The results for each neighbourhood are shown in Figure 12. There was no significant difference in urinary inorganic arsenic in children by neighbourhood or gender.

The results for urinary inorganic arsenic are summarized in Table 7 for easy reference.

Figure 10: Frequency Distribution of Urinary Inorganic Arsenic Children 1 to 5 (n=179)

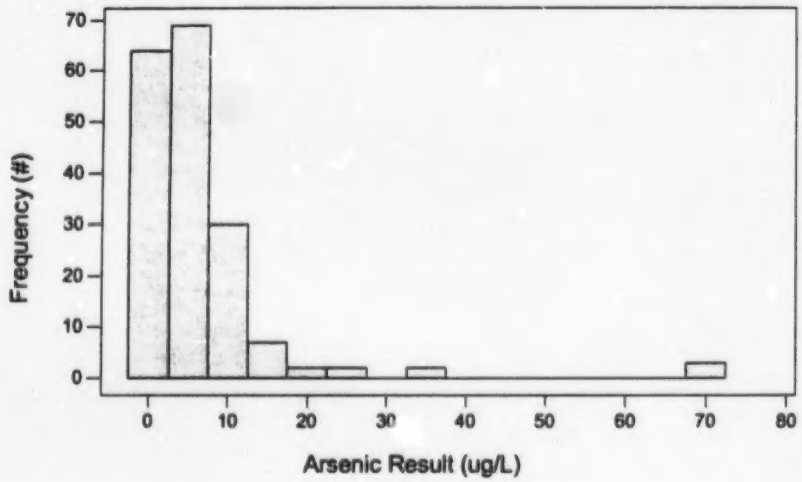


Figure 11: Box Plot of Urinary Inorganic Arsenic Children 1 to 5 (n=179)

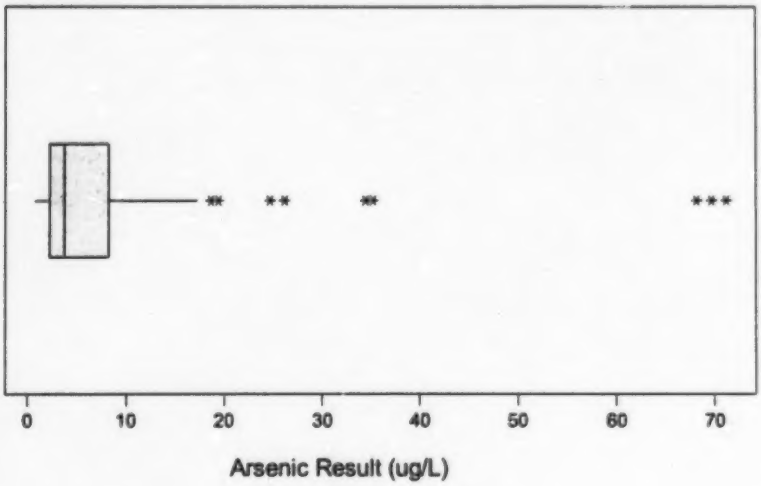


Figure 12: Box Plot of Urinary Inorganic Arsenic Children 1 to 5 By Neighbourhood

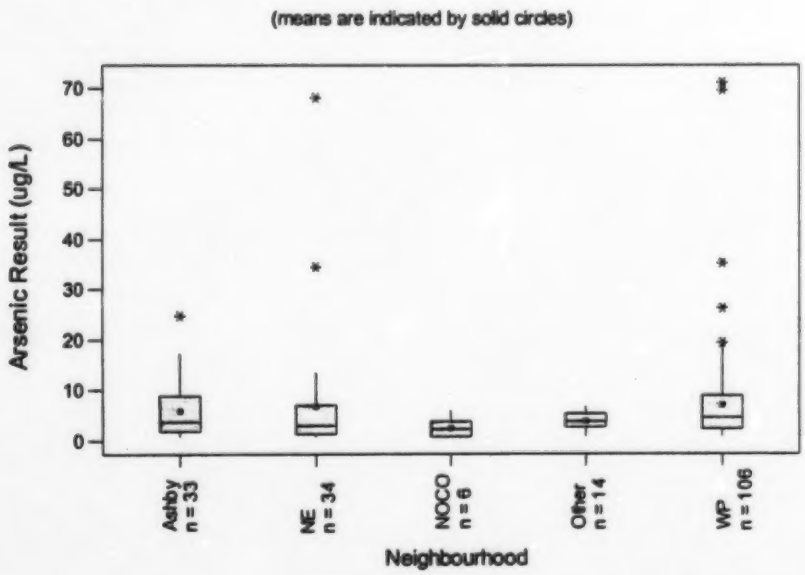


Table 6: Summary of Urinary Inorganic Arsenic Results (ug/L) for all Ages and for Children

		N	Mean	Geometric Mean	Median	Min	Max	25th Percentile	75th Percentile
All Ages	All Tested in Target Area	372	6.40	4.11	4.49	0.75	71.16	2.25	8.05
	Others	35	5.59	4.65	5.24	0.75	14.98	3.00	6.74
Children 1 to 5 years	All Tested in Target Area	179	6.60	3.75	3.75	0.75	71.16	2.25	8.24
	Others tested outside target area	14	3.85	3.43	3.75	0.75	6.74	2.81	4.87

Individuals requiring follow up

Initially eleven individuals who attended the community clinics had urinary inorganic arsenic results above 20 ug/L and required follow up (Table 7). As part of the follow up process, all family members not yet tested were offered testing. This process resulted in finding three other individuals in these families (for a total of 14) with urinary inorganic arsenic levels above 20ug/L; siblings in two cases and a parent in another case. One more individual tested through their family physician, had a urinary inorganic arsenic result above 20 ug/L for a total of 15.

The fifteen individuals (4.0% of all tested in the target area) requiring follow up included 7 children ages 1 to 5, 4 children between age 6 and 17, and 4 adults. Three (3) lived in NOCO, 6 lived elsewhere in Whitney Pier, 4 in the North End and 2 in Ashby. No pregnant women required follow up. Figure 13 shows the inorganic urinary arsenic results for the first test (first void urine) and for the follow up test (24 hour urine sample) for each of these 15 individuals. Thirteen (13), out of 15, had urine inorganic arsenic results less than 20 ug/L on repeat testing on a 24-hour urine sample. No obvious sources of arsenic exposure were evident except in one child who had ingested a large meal of lobster and mussels a day or two before testing. This type of seafood contains inorganic as well as organic arsenic, which can lead to high test results (Vahter and Lind 1986, Polissar et al.1990).

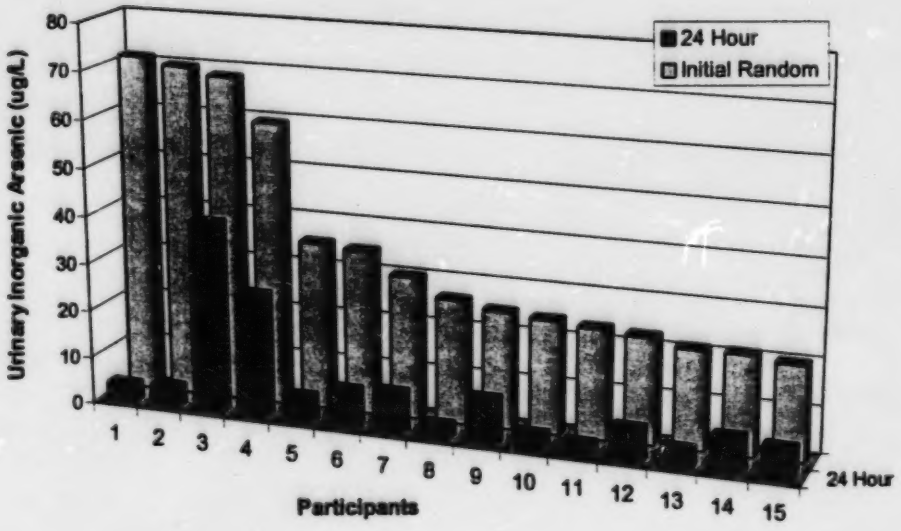
In the box plot in Figure 8, four urine inorganic arsenic results stand out above the others. The three highest results are children between ages 1 to 5. The fourth is an older child. Two of these children had urinary inorganic arsenic levels above 20 ug/L on 24 hour urine testing. These two children and at least one other child had detailed medical assessments by a specialist. No arsenic related health effects were found.

Nine properties underwent detailed soil sampling. The results were compared against short-term exposure guidelines. One property had an area on initial screening that exceeded the short-term exposure limit for lead (JDAC 2001) but not for arsenic. This area was fenced off and more testing was done to determine the size of the area with high lead levels. The results of the property specific chronic risk assessments are not yet available.

Table 7: Urinary Inorganic Arsenic Results All tested, Results ≥ 20 micrograms/L

	Ashby	NOCO only	WP not including NOCO	North End	Total
Children 1 to 5 years	1	0	4	2	7
Children 6 to 17	0	2	1	1	4
Pregnant Women	0	0	0	0	0
Other Adults	1	1	1	1	4
Totals	2	3	6	4	15
Proportion of those tested	3.6%	4.5%	3.1%	6.9%	4.0%

Figure 13: Initial Random and Follow up 24 Hour Urinary Inorganic Arsenic Results



Comparison with Other Communities

There are few Canadian based surveys of urinary inorganic arsenic reported in the literature. Table 8 shows results from similar studies in Deloro Ontario (community with arsenic in the soil related to mine tailings) and in Wawa Ontario (arsenic in the soil related to an iron ore sintering plant) along with results from a control community, Havelock Ontario (Ontario Ministry of the Environment 1999, Goss Gilroy Inc 1999, Goss Gilroy Inc 2001).

All of the information required to compare results from Sydney with results from Deloro, Havelock or Wawa is not available in published reports. For example, Sydney data have some high values, which effectively increase the mean value for the population. In these situations, the median is more useful for comparison purposes but the median values are not readily available for Havelock and Deloro. However, some comparisons can be made.

The median urinary inorganic arsenic value for all ages and all tested in Sydney is 4.49 ug/L while the mean is 6.40 ug/L. This is comparable to the median for Wawa (4.37 ug/L), the mean for Wawa (5.62 ug/L), the mean for Deloro (4.36 ug/L) and the mean for Havelock (4.57 ug/L). The mean values for children in all communities are very similar. There are two notable features of the results from Sydney. The maximum value of 71.16 ug/L (before confirmatory testing) is higher than that seen in the Ontario communities. In addition the proportion of those with levels at or above 20 ug/L is higher in Sydney (4.0%) than in Deloro (3.3%), Havelock (1.9%) and Wawa (1.6%). These differences are not clinically significant, that is, they are within the range of variation for populations in a variety of settings and are not associated with individual or population wide health impact.

It is important to note that no statistical difference was found in levels of arsenic in urine between Deloro and the comparison (control) community of Havelock where there is no known arsenic contamination (Ontario Ministry of the Environment 1999, Goss Gilroy 1999). Similiarly, comparison of Wawa data with Havelock data indicated that overall, Wawa residents had similar levels of inorganic arsenic. In other words, even though these communities were known to have elevated arsenic in soil, urinary inorganic arsenic levels in these communities are similar to a community in which no environmental arsenic exposure is expected. The same appears to be true for the neighbourhoods around the Coke Ovens site.

Table 8: Urinary Inorganic Arsenic (ug/L) in Canadian Populations

	Study Location	Reference	N	Mean (SD)	GM	Median	Min, Max	# > 20 ug/L	Detection Level (ug/L)
All Ages	Wawa	Goss Gilroy Inc 2001	184	5.62 (4.35)		4.37	0.28, 25.22	3 (1.6%)	0.2
	Havelock	Goss Gilroy Inc 1999	53	4.57 (3.98)			3.0, 19.99	1 (1.9%)	6 *
	Deloro	Goss Gilroy Inc 1999	121	4.36 (4.0)			3, 23.44	4 (3.3%)	6 *
	Sydney,NS All tested	Current Report	372	6.40 (8.17)	4.11	4.49	0.75, 71.16	15 (4.0%)	0.5
Children	Wawa-under 13 years of age	Goss Gilroy Inc. 2001	44	6.99 (5.10)		5.52	0.28, 20.46		0.2
	Havelock-under 13 years of age	Goss Gilroy Inc 1999	8	7.01 (4.44)			3.0, 12.72	0	6 *
	Deloro-under 13 years of age	Goss Gilroy Inc 1999	26	5.34 (5.59)			3.0, 22.93		6 *
	Sydney,NS Under 13 years of age	Current Report	236	6.74 (9.53)	4.05	4.49	0.75, 71.16	10 (4.2%)	0.5
	Sydney,NS Ages 1 to 5 years	Current Report	179	6.60 (9.94)	3.75	3.75	0.75, 71.16	7 (3.9%)	0.5

* When the detection limit is 6 ug/L a report of a non-detectable level was assumed to be 3 ug/L which is one-half of the detection limit.

Table 9 shows some results from studies in Europe and the USA. These results have been chosen as examples of different circumstances and are not meant to be all-inclusive. Vahter and Lind (1986) reported an average concentration (geometric mean) of speciated (inorganic) arsenic in urine in two cities in Sweden of 9.1 ug/L and 7.9 ug/L. The authors go on to note that similar urinary concentrations of inorganic arsenic and its metabolites have been reported from Belgium, the Federal Republic of Germany, Finland and Italy. Somewhat higher concentrations of approximately 20 ug/L have been reported from the U.S.A and approximately 50 ug/L have been reported from Japan. The levels in Japan may be associated with the high concentration of inorganic arsenic in algae, which is a common ingredient in the Japanese diet (as reported in Vahter and Lind 1986). Vahter and Lind also noted that there were 11 samples in their study with greater than 20 ug As/g creatinine. All samples were from cities that do not have any industries emitting large amounts of arsenic.

The German Environmental Survey 1990/1992 determined the geometric mean urinary inorganic arsenic level for the German population to be about 6.29 ug/L. Seifert et al. (2000) note that 12.4 % of the adult population and 12.7 % of children showed mean urinary inorganic arsenic higher than 15 ug/l. 3.6 % of the adults and 2.2% of children showed a value higher than 40 ug/l. They noted that arsenic levels measured at one point in time do not necessarily reflect the permanent status of an individual. They offered repeat measurements to persons with values above 15 ug/L. The samples were taken on another day and mostly did not confirm the primary values. Generally, the elevated concentrations measured in the first round could be traced to fish consumption on the days preceding sampling (Seifert et al 2000, Trepka et al 1996).

In addition to population-based surveys, the literature includes examples of urine arsenic results in communities in industrial areas. Pollissar et al (1990) reports on exposure to arsenic in a community surrounding a copper smelter in Tacoma, Washington. They studied people at varying distances from the smelter and found that boys and girls age 0 to 6 living within one-half mile of the smelter had median urinary inorganic arsenic concentrations of 48.0 ug/L and 24.5 ug/L respectively. All other groups of males and females ages 7 to 13, 14 to 19, and 20+ had median urine concentrations ranging from 4.5 to 17.0 ug/L similar to those in their control community. Overall, 10% of the urine samples in the study area had concentrations above 50 ug/L and 3% had concentrations above 100 ug/L. Urinary concentrations of arsenic fell off to a background level within one half mile of the smelter.

Table 9: Urinary Inorganic Arsenic (ug/L) in other Populations

Study Location	Reference	N	Arithmetic Mean (SD)	Geometric Mean (SD)	Median	Min	Max
Sydney, NS All ages	Current report	372	6.40 (8.17)	4.11	4.49	0.75	71.2
Stockholm, Sweden Ages 21 to 72	Vahter and Lind 1986	49	12.4 (11.3)	9.1 (2.1)	7.9	2.3	53.4
Vasteras, Sweden ages 21 to 72	Vahter and Lind 1986	50	9.7 (7.3)	7.9 (1.9)	7.4	1.7	40.3
Anaconda, Montana USA -Children < 6 years	Hwang et al 1997	289		8.6 (1.7)			11.4
Tacoma, WA a) Ruston (0.3 mi from smelter)	Polissar et al 1990	649		19.4 (25.3)	11.4		
b) Bellingham –control community	Polissar et al 1990	61		10.1 (5.5)	9.5		
German Environmental Survey 1990/1992 Adults	Seifert et al 2000	4001	10.52	6.29 CI 6.08 to 6.51	7.1		206
German Environmental Survey 1990/1992 Children ages 6 to 14	Seifert et al 2000	731	9.50	6.01 CI 5.56 – 6.51	7.0		104
Children in East Germany Ages 5 to 14	Trepka et al 1996	950		4.7 (4.5 to 5.0)	5.0	0.3	89.2

Summary of Urinary Inorganic Arsenic Results

Three hundred and seventy-two (372) persons from the target area were tested for urinary inorganic arsenic including 179 children ages 1 to 5. Forty two percent (42%) of the children and 61% of pregnant women and 30% of residents of NOCO were tested.

Urinary inorganic arsenic levels averaged 4.49 ug/L for all ages tested and 3.75 ug/L for children. Ninety-six percent (96%) of the results were below 20 ug/L, the level at which detailed follow up took place. Of the 15 individuals with levels above 20 ug/L on the initial test, only 2 remained above this level after definitive confirmatory testing done on 24-hour urine samples.

The urinary inorganic arsenic levels in Sydney were comparable to the three Canadian communities, for which data were available with the exception of the maximum value which was higher than in the other three communities. The proportion of individuals with initial urinary inorganic arsenic levels at or above 20 ug/L was 4% in Sydney compared to 1.6 to 3.3% for the Ontario communities. However, the average inorganic urinary arsenic levels in Sydney and other Canadian communities were lower than populations living in the US and Europe in areas with and without localized sources of arsenic. The

maximum values in Sydney as well as the proportion of individuals with values above 20 ug/L were also lower in Sydney than in many other populations including areas without localized sources of arsenic.

Discussion

General

This testing program measured current exposure to lead and arsenic in specific neighbourhoods around the Coke Ovens site. The target groups were children (ages 1 to 5), pregnant women and all residents in NOCO where lead and arsenic had been identified in the soils of the neighbourhood. In addition, family members of individuals whose test result was above the pre-determined follow up level, were offered testing in order to assess a potential family-associated exposure. Some individuals sought testing through personal physicians. All results of tests done for blood lead and urine arsenic on individuals in the target area are included in this report.

Cross Sectional Design

The design of the program maximized the opportunity to find significant elevations in blood lead or urinary arsenic levels if they existed. The testing was done during the warm summer months (June, July and August) when more time is spent outdoors and opportunity for exposure from soil and dust is at its peak compared to winter months. The focus was on children, who are most likely to be exposed to soil as a result of hand to mouth activity and outside play. In addition, testing was offered to all residents in NOCO where arsenic and lead had been identified as concerns during environmental assessment.

One limitation of the cross sectional approach is that exposure assessed at one point in time may not reflect longer term or cumulative exposure. This is particularly true for urinary inorganic arsenic testing which measures exposure for the last few days only. If an individual was outside of the area of contamination for a few days before testing, their result would reflect exposure from elsewhere and not be a true measure of local residential arsenic exposure. This is not a problem with lead testing, since at low levels of exposure, blood lead reflects both current exposure and cumulative exposure.

Just prior to the testing program, a risk assessor made a public recommendation that individuals in the NOCO area should take steps to decrease soil exposure. It is not known how many families were aware of this advice, and actually followed it with the result that exposure at the time of testing may have been lower than would have occurred without this intervention

Sampling Strategy and Response Rates

This testing program was designed as a public health service to measure current exposure rather than as an epidemiological study linking biological test results for current exposure with health effects or with environmental sampling results, or any other risk factors for increased exposure. Therefore there was no specific sampling strategy or attempt made to collect confounding factors. Instead testing was offered to all members of the target group. In addition some individuals outside of the target group sought

testing on their own. The results for everyone tested in the target area were included in the analysis because this is an important issue in the community and all available information should be included in public health decision-making. In addition, the increased sample size gives a better estimate of population exposure to arsenic and lead.

Since those tested were not randomly chosen from the population, there is the possibility that the tested population is not representative of the general population in the target area. Such would be the case if a bias towards testing were expressed by those who actually have more or less exposure than those not tested. We have no reason to believe that failure to volunteer, in this community, is differentially related to exposure opportunity.

The response rate for children in the target area was 44% for lead and 42% for arsenic. This is low considering that there has been so much concern in the community about exposure to lead and arsenic from local contamination. However, the requirement for venipuncture to obtain the blood for lead testing may have deterred some parents from bringing their children in for testing. Thirty percent (30%) of residents of NOCO, the neighbourhood where lead and arsenic were identified in the soil, were tested. Detailed information (such as age and sex) is not available on those who chose not to get tested so it is not possible to compare the differences in these characteristics between those tested with those not tested.

Notwithstanding the limitations discussed above, the results provided by this population constitute an important contribution to the knowledge about inorganic arsenic and lead exposure in Canadian communities.

Measure of exposure, not health effects

It is important to note the tests used here represent exposure, not health effects. Many factors influence what actually enters the body from the environment. These include personal hygiene habits, age, gender, daily activities etc., which result in considerable variation.

While there are clear guidelines for interpreting blood lead results, both on an individual and a community basis, no such guidelines exist for urinary arsenic. In biomonitoring programs in the occupational setting, a urinary inorganic arsenic level of 35 ug/L is used as a level at which exposure should be assessed. This occupational intervention level is based on lung cancer risk from inhaled arsenic. A urine inorganic arsenic level of 20 ug/L was used in this testing program as a level to trigger a more detailed assessment of exposure of the individual. This was based on reports found in the medical literature, consultation with experts and reviews of other community studies. No health effects are expected at this level. However, considerable anxiety faced many parents whose children showed levels of inorganic arsenic in urine above the benchmark selected for follow up in this study. Some parents interpreted any level above the benchmark to mean that their child would experience health effects from this level and that, even if the child were healthy now, there might be long-term health effects.

Urine Concentration and Interpretation of Arsenic Levels

Urine arsenic results are reported by the laboratory as a concentration (ug/L) or as an amount of arsenic per amount of creatinine. This second unit of measure, arsenic amount per creatinine amount corrects for urine volume and fluid intake, as well as kidney function. There is no standard validated method to correct for urine concentration that applies to all ages and to males and females, so we chose to use the concentration in ug/L as the units for follow up of individuals and for reporting.

Of the 15 individuals with a first urine result of 20 ug/L or above, all but two had subsequent urinary inorganic arsenic levels below 20 ug/L measured in a 24 hour urine collection. It is not possible to say if this decrease in urinary arsenic level was due to decreased exposure since the first test, or if the first urine sample was concentrated compared to the more definitive 24-hour urine collection.

Community Comparisons

From the community viewpoint, comparison of this community's results with other communities and with published population reference levels is helpful in interpreting the results of this testing program and in guiding efforts to limit exposures. However, it is important when making comparisons to note that laboratories may use different techniques and have different detection levels.

Conclusions

To date the biological testing program has met its objectives. Residents living near the Coke Ovens were provided with the opportunity to be tested for lead and arsenic. They have received their personal results and interim advice on reducing exposure if required. Further advice will be given after the property specific chronic risk assessments are completed.

The results reflecting lead exposure in the community are very reassuring. Lead levels in this community are low, and reflect levels of exposure similar to areas where there is no identifiable soil lead exposure source. From a public health perspective, this community is not at increased risk from lead in soil.

On the community level, arsenic exposure is also low. While there were individuals with initial results higher than the general population of those tested, all but two of these were within the same range as the general population on repeat confirmatory testing. This is not unexpected since exposure varies from day to day and from person to person. The overall community profile resembles other areas, both with and without localized sources of arsenic in soil.

The results and conclusions from this biological testing program will be considered alongside the results of the property-specific chronic risk assessments when available in order to develop further recommendations if required.

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Glossary

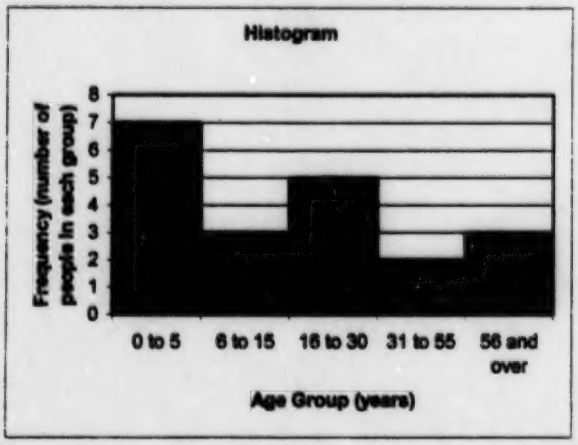
Box and whisker plot: The box-whisker plot gives a summary of key features of a distribution of values. The box in the plot gives the lower and upper quartiles, with the line in the middle being the median. A dot, when given, is the mean. Thus, the lower and upper edges give the inter-quartile range (IQR), an estimate of the middle 50% of the population grouped around the median. The whiskers extend from the edges to the maximum and minimum values, or 1.5 times the IQR, whichever is less distant from the box. For approximately normal data, the whiskers estimate values that would include about 95% of the population. If any observations are further than 1.5 times the IQR from the box (i.e., beyond the whiskers), they are shown as asterisks, and may be outliers.
Example: Figure 2

Descriptive Statistics: Descriptive statistics are methods used to summarize or describe the data (results). This includes information like the mean, the standard deviation, median and the range.

Frequency: The number of members of a population or statistical sample falling in a particular group.

Frequency distribution: A display of an ordered set of values and the frequencies for each value.
Example: The following table and histogram (a block diagram whose blocks are proportional in area to the frequency in each group) show the number (frequency) of people that fall into each category in a group of 20 people.

Age group (years)	Number of people in that age category
0 - 5	7
6 - 15	3
16 - 30	5
31 - 55	2
55 and over	3



Interquartile range: The region covered by the two middle quartiles, or fourths, in a set of data.

Transformation: Sometimes data not compatible with a normal distribution can be transformed mathematically (usually log transformed) to make them acceptably near to a normal distribution. This allows the application of parametric methods to analyze the data.

Mean: The average found by dividing the sum of all values (results) in a set, by the number of values in the set.

Geometric mean: The mean of the log transformed data, back-transformed (or antilog). This mean is similar to the median.

Median: The middle value in a set of values that have been arranged from lowest to highest. If there is no middle value, the median is the average of the middle two values. Half the data lies above the median and half lies below.

Non parametric methods: Statistical methods that don't require the data to be normally distributed or follow a bell curve.

Normal Distribution: With normally distributed data, approximately 68% of the data lies within 1 standard deviation of the mean and 95% of the data fall within 2 standard deviations.

Outlier: A value whose distance from the first or the third quartile is more than 1.5 times the interquartile range.

Parametric methods: Statistical methods used on data that is normally distributed (follows a bell curve).

Population: The whole group of people or things that are being studied.

Random Sample: A sample selected in such a way that every member of the population involved has an equal chance of being included.

Range: The difference between the highest (maximum) and lowest (minimum) values in the sample.

Sample: The part of the population on which information will actually be collected.

Skewed: A word used to describe a frequency distribution in which values are clustered at one end of the scale and spread out at the other. For example, a distribution that is high at the extreme left and trails off on the right side is said to be positively skewed. eg. Figure 1

Standard Deviation: How far the data or results deviate from the mean.

Source

Altman, D. 1991. Practical Statistics for Medical Research . Chapman & Hall, London, UK.

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